



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

FACTORS WHICH INFLUENCE THE AROUSAL OF THE PRIMARY VISUAL MEMORY IMAGE

By HAROLD E. BURTT, Harvard University

I. Introduction.	87
II. Apparatus and method.	89
III. Experimental results	95
A. Complexity of contour.	95
B. Size.	99
C. Length of exposure.	101
D. Interest.	104
E. Motor reinforcement	108
F. Motor distraction	109
G. Mental distraction	112
IV. Summary.	115
A. General tendencies	115
B. Individual differences	115
C. Conclusions.	117

I. INTRODUCTION

The development of the problem of individual differences in imagery subsequent to the time of Galton has led away from the original simple solution to an increasing realization of the complexity of the whole matter. We note the failure of investigators to find simple types and the disputes as to the actual criteria of type. Fernald has recently stated that "individual differences in imagery are too complex to be stated in terms of differences in type unless this type is carefully explained in the individual case,"¹ and suggests that perhaps "individual differences may be more profitably stated without the incubus of types,"² while Lipmann³ thinks that a further differentiation is necessary within the visual according as individuals best apprehend (auffassen) hue, saturation, brightness, size, or position.

In view of the present rather unsatisfactory status of the traditional problem of types, and of the nevertheless patent fact that individuals differ markedly in their mental imagery, the present investigation proposes to approach a limited aspect of the question within the field of visual imagery. The effect of certain fairly controllable factors connected with a visual

¹ M. R. Fernald, The Diagnosis of Mental Imagery, *Psychological Monographs*, XIV., 1912 (No. 58), 130.

² *Ibid.*, 21. ³ O. Lipmann, Visuelle Auffassungstypen, *Bericht IV Kongress für experimentelle Psychologie*, 1911, 198.

stimulus upon the immediate arousal of visual imagery of that stimulus was studied. Complexity of contour, size, length of exposure of an object, interest aroused in an object, motor reinforcement by tracing, motor distraction and mental distraction during fixation were selected for investigation and their effect upon imagery of the object was determined. These are only a few of the many variables that might be made the subject of profitable study.

The determination of imaginal types in the present case is wholly incidental. The interest of the experiment is four-fold:

1. How far do the above factors, operative during a period of visual stimulation, influence, in general, the arousal of imagery of the stimulus?

2. How far do individuals differ quantitatively in their susceptibility to these various factors?

3. How far do individuals differ qualitatively in the means by which these factors operate in influencing the arousal of visual imagery?

4. How far, if at all, are these factors interrelated?

Two previous experiments have dealt specifically with a few of the above factors. Meakin,⁴ working with pairs of plane figures and noting the subsequent rivalry in imagery, finds that the larger or longer-exposed object or that with a notched contour persists in consciousness during a greater part of a given interval than does a simple object. Murray,⁵ working with single exposures of simple figures, finds no correlation of duration or excellence of reproduction in imagery with complexity and size.

The other factors involved in the present investigation have been brought out only incidentally in previous experimental studies. Meakin⁴ mentions interest as a cause for the more frequent occurrence of images of certain figures. Kuhlmann⁶ using pictures of familiar objects as stimuli for imagery, concludes that the tendency for the image of a picture to become that of a real object is due to the fact that there is "more interest and emotional coloring to objects than to pictures." Martin⁷ notes that, according to the introspection, the duration of imagery frequently depends on interest.

⁴ F. Meakin, Mutual Inhibition of Memory Images, *Harvard Psychological Studies*, I., 1903, 235-275.

⁵ E. Murray, Peripheral and Central Factors in Memory Images of Visual Form and Color, *American Jour. of Psychol.*, XVII, 1906, 227.

⁶ F. Kuhlmann, Memory Consciousness for Pictures of Familiar Objects, *American Journal of Psychology*, XVIII, 1907, 420.

⁷ L. J. Martin, Die Projektionsmethode und die Lokalisation Visuel-
ler und anderer Vorstellungsbilder, *Zeits. für Psychologie*, LXI, 1912.

The motor element in visual imagery is repeatedly emphasized by Meakin and he concludes that the factors which he studied (such as size, complexity, broken lines, etc.) are the "conditions which determine the energy diversity, complexity and definiteness of the active process involved in the bestowal of attention upon its object, and . . . such active processes are as essential in ideation as in perception."⁸ Kuhlmann, using meaningless forms which are memorized and recalled after an interval, finds motor tendencies in the imagery and these are in some cases "real aids to recall."⁹

Meakin mentions attention in the above quotation. Slaughter¹⁰ notes that the distribution of attention in imagery and stimulus are similar. If a row of dots is followed across with the eyes, the dots can be brought out successively in imagery. Martin⁷ states that, according to the introspection of the subjects, the duration of imagery often depends upon attention. Distraction has sometimes been employed in tests of imaginal type. The mode of distraction (visual, auditory, verbal) which produces the greatest effect upon the objective results of a learning "Aufgabe" is supposed to indicate that the subject belongs to the corresponding type. The method has been used with considerable success by some investigators, but it is sometimes found that the distraction has no effect upon the imagery.¹¹ In the present experiment, however, the method is somewhat different,—the distraction being employed during the stimulus period and the effect upon *subsequent* imagery noted.

II. APPARATUS AND METHOD

Each of the seven variables above mentioned was studied, in the present investigation, from three standpoints.

1. *Single* exposures were made of simple geometrical figures, some trials involving and others not involving the given variable. The time necessary for arousal and the time of involuntary holding of subsequent imagery under the former condition was compared with that under the latter.

2. *Simultaneous* exposures were given of two figures, one of which involved the variable under consideration. The rela-

⁸ F. Meakin, Mutual Inhibition of Memory Images, *Harvard Psychological Studies*, I, 275.

⁹ F. Kuhlmann, Mental Imagery and Memory of Meaningless Forms, *Psychological Review*, XIII, 1906, 344.

¹⁰ J. W. Slaughter, A Preliminary Study of the Behavior of Mental Images, *American Journal of Psychology*, XIII, 1902, 535.

¹¹ Cf. J. E. Downey, Central Processes in Modified Handwriting, *Psychological Monographs*, IX, 1908 (No. 37), 99.

tive predominance of the two in imagery was noted, and compared with the results of the check series in which neither figure involved the variable. The times of arousal and holding of the imagery under the two conditions were compared.

3. The *successive* exposure of two simple figures in check series usually yielded a marked predominance of the second in subsequent imagery. By introducing a hypothetically reinforcing variable on the first object or a distracting one on the second, the effect in reducing the predominance of the second could be noted. The times of arousal and holding of the image in the crucial and check series were compared.

The variables were controlled by the nature of the stimulus object or by the "Aufgabe" during the stimulus period. Figures with notched edges, with twice the usual area, with longer exposure, or figures representing in outline certain meaningful objects, were used to control complexity, size, exposure length and interest respectively. Motor reinforcement consisted in the subject's tracing a figure on the table while fixating it. Motor distraction was produced by writing extraneous words during fixation. Mental distraction consisted in performing mental addition while observing the figure.

An experiment of this sort necessitated an exposure apparatus that would provide a means of eliminating sensory after-images by a flash of light prior to the mid-period, and that would accurately control the time relations of the stimuli.

A few of the earlier series were performed with a relatively crude apparatus, Hering's *Nuancierungsapparat* adapted for the purpose. This consisted of a box 94 x 30 x 20 cm. with one of the broader sides open, and mounted vertically with the open side facing a north window. The subject sitting on a high stool with his forehead on a rest, could see, through a small aperture in the top of the box and through a diagonal piece of glass, the black rectangular field at the bottom. When the experimenter pulled a string, a black cover fell across this field and automatically opened a door on the side of the box which admitted light reflected from a piece of milk glass outside. This light was reflected upward from the diagonal piece of glass in the box to the eye. The stimulus object of black cardboard was placed on the field and at the signal "ready-open," the subject opened his eyes and fixated the object for 5 seconds until the experimenter, noting a stop-watch, pulled the string. As soon as the flash appeared the subject closed his eyes and observed the imagery that arose, signalling its appearance and disappearance by raising

and lowering the finger. The experimenter took the time with a stop-watch.

The majority of the work, however, was performed with an enlarged and somewhat modified Dodge tachistoscope.¹² This consists in principle of a box with black interior with two exposure fields at opposite corners visible through an opening at the third corner,—one field, when illuminated, seen directly through a diagonal piece of smoked glass and the other, when illuminated, seen reflected from the glass which with dark background acts as a mirror. The present apparatus was 25 cm. deep with the 25 x 25 cm. fields 96 cm. from the rectangular opening hooded for the eyes of the subject. The fields were illuminated by light from two 25 watt tungsten lamps reflected by mirrors outside the range of vision. A third lamp was placed inside the apparatus just to the right of the smoked glass in such a position that its filaments were thrown out of focus on the eye by a 10 cm. condensing lens. A slit 70 x 8 mm. in a cardboard screen admitted a small portion of the light from the filaments. This was sufficiently strong to destroy the after-image, but not sufficiently so to cause discomfort. The lamps were on separate circuits and by proper control the stimulus objects appeared successively in the same apparent position followed by the flash of light. The apparatus rested on legs on a table with the hood on the level with the eyes of the subject sitting on an adjustable chair. The experimenter sat at one side of the apparatus at a table containing the switch-board, stop-watches and material for stimuli.

A slit was cut in the cover of the apparatus above each of the exposure fields to admit the insertion of pieces of 25 x 25 cm. cardboard with the stimulus objects pasted or drawn upon them. One field could be reached from the experimenter's seat, but the other could not without standing up and reaching across the apparatus. At this latter were installed four traveling frames of light brass suitable for holding stimulus cards. Their contiguous surfaces were perfectly smooth and they were operated from the experimenter's seat by strings and pulleys so arranged that any frame could be pulled into position and the others drawn to one side. The field was masked so that no brass was visible. The frames were loaded at the beginning of the hour's work and it was thus possible to avoid much confusion and save considerable time during the series.

¹² Cf. R. Dodge, An Improved Exposure Apparatus, *Psychological Bulletin*, IV, 1907, 10-13.

The length of exposure of the stimuli was controlled by means of the circuits through the lamps. A wooden disc 22 cm. in diameter, mounted on an axis, was driven at the rate of 3 revolutions per minute by an alternating current motor reduced by belt gear. On this disc were mounted three brass contacts in the form of arcs of circles of different radii having the axle as the common center. The radius drawn to the end of one arc marked the beginning of the next, so that, as the disc revolved, they would in succession pass a given radius. Three contacts of spring brass, with their free ends in the same line were adjusted to press in succession upon the contacts on the disc. Thus during a part of the revolution the first spring contact was on the first contact on the disc; just as it reached the end of the arc and pressed against the wood, the second spring contact pressed on the second contact on the disc, etc. The contacts on the disc were connected with the axle and mounting and thus to one pole of the lamp circuit. The three spring contacts led through the three lamps respectively and joined at the other pole of the main line. Thus the three lamps were lighted in succession, one disappearing just as the next appeared. The first arc on the disc was stationary and of the proper length to give a 6 second exposure. The second was pivoted at the end nearest the first and held in position by friction in a narrow slit sawed in the wood along the arc. The length of the contact could be shortened by pushing the free end farther through the disc so that the spring that rested on it would touch merely the wood. The third arc was of the proper length to give a one-second exposure and was soldered to a strip of brass passing under a screw clamp at the axle so that it could be moved along in a shallow groove to a position immediately following the end of the second contact. Thus the two objects in the tachistoscope could be shown successively for various lengths of time followed by the flash of one second. When it was desired to use single exposures a switch in the circuit of the first lamp was opened. Other switches made it possible to reverse the order in which the first two lamps were lighted or to have one lamp lighted by both of the first two contacts. In part of the work, the motor and lamp-controlling mechanism set on a table with the tachistoscope, but later they were moved to an adjoining room and the wires led through the wall. The sound of the motor was never noted as a distraction by the subjects and furthermore it was a constant factor.

To record the time of arousal and holding of imagery two stop-watches were used. One was of the football type, started

and stopped by plungers at the side. It was mounted with two short strips of brass, each pivoted at one end resting on the respective plungers. The free ends were connected by light steel wires through screw eyes to the armatures of two telegraph sounders. These latter was actuated by a make-and-break key operated by the subject. With the key in its normal position the sounder which pulled the lever against the "stop" plunger was in operation. When the subject pressed his key it broke that circuit and closed one through the other sounder which actuated the "start" plunger. When the key was released the original circuit was again closed. This watch was used to record the time of holding of the image. The other watch was of the ordinary stem starting type and was mounted horizontally with a strip of band iron pivoted a short distance to one side of the stem. Opposite the end of this was a horseshoe electromagnet which could be operated by two parallel circuits. The first of these was closed by a contact at the proper point on the rotating disc which controlled the exposures in the tachistoscope,—a piece of brass on the disc brushing across two poles 2 mm. apart. The second circuit was closed by a relay in connection with the sounder which started the first watch. Thus the watch started automatically just as the second object disappeared in the tachistoscope, and stopped when the subject signalled the presence of the image by pressing the key.

The materials for the experiment consisted, except in the series on interest, of simple geometrical or meaningless figures. None of the polygons had more than six sides and the curved figures were comparatively simple. The figures were uniformly of 36 sq. cm. area with the exception of some of twice that area used in the study of the effect of size. Those used in the "*Nuancierungsapparat*" were cut from black cardboard and were exposed upon a field of the same material. Those employed in the Dodge tachistoscope were of white paper pasted on black cardboard, or were drawn in outline with ink on light grey cardboard. Those used in single and successive exposures were centered on the card. Those used in simultaneous exposures were side by side with a space of 2 cm. between their nearest points. In the latter case the space error was always obviated by presenting the two figures in both space orders in different trials. Similarly the time error on successive exposures was controlled,—the same figure occurring first in half of the trials in which it appeared, and occurring second in the other half.

The instructions given to the subjects in previous experi-

ments involving a definite visual Aufgabe have varied considerably. Meakin¹³ and Murray¹⁴ instructed their subjects to await passively the entrance of the image into consciousness. Martin¹⁵ and Ogden¹⁶ told theirs to "get an image." Perky's instructions¹⁷ were to be on the lookout for images. In the present experiment the subjects were given two hours of preliminary training in which they were instructed to "call up a visual image of the object just seen, observing it as passively as possible and signalling its presence by pressing the telegraph key and its disappearance by releasing the key." These instructions rapidly passed into a determining set and in all subsequent work, after being told to fixate the figures that appeared or to fixate between them (on simultaneous exposures) or to perform the required operation during fixation, the subject was merely instructed to "close the eyes after the flash and observe whatever imagery arises, pressing the key when the image appears and releasing it when the image disappears." These instructions were given at the outset of the hour's work and not repeated during the series. After each trial the subject described the image and the introspection was recorded verbatim.

Visual stimuli seemed more suitable for an experiment of this sort than word stimuli, for they afford a better objective control of the variables under investigation. Word stimuli would in the present case be more liable to introduce extraneous factors such as suggestion. Moreover the visual stimulus affords a better control of the subject's state during the fore-period, for he is always observing a figure for 5 or 6 seconds prior to the mid-period in which the image appears.

That after-images did not play a part in the experiment seems evident from the intensity of the flash that followed the exposures. The subjects frequently noted a momentary after-image which was "wiped out" by the flash. Furthermore the qualitative aspect and the temporal course of the images for a given subject were fairly similar whether the

¹³ F. Meakin, Mutual Inhibition of Memory Images, *Harvard Psychological Studies*, I, 1903, 237. ¹⁴ E. Murray, Peripheral and Central Factors in Memory Images of Visual Form and Color, *American Journal of Psychology*, XVII, 1906, 229.

¹⁵ L. J. Martin, Die Projektionsmethoden und die Lokalisation Visueller und anderer Vorstellungsbilder, *Zeitschrift für Psychologie*, LXI, 1912, 329. ¹⁶ R. M. Ogden, Experimental Criteria for Differentiating Memory and Imagination in Projected Images, *Psychological Review*, XX, 1913, 379.

¹⁷ C. W. Perky, Experimental Study of Imagination, *American Journal of Psychology*, XXI, 1910, 428.

stimulus was a white figure on a black field, a black cardboard figure on a black ground or a figure drawn in outline with ink on a grey card.

In some of the previous work of other experimenters the imagery has been observed during a definite interval,—frequently a minute,—the successive appearances of the image being recorded. The present work dealt only with the primary visual memory image. Subsequent recurrences after the first disappearance of the image were not taken into consideration. In one series the times for the primary and for the recurring image (i. e. the total time the image was present during a minute) were recorded for four subjects,—about 60 trials each. The coefficients of correlation between the two times by the Pearson product-moments formula were:

$$\begin{array}{r} .6056+.063 \\ .4710+.089 \\ .4298+.089 \\ .4004+.075 \end{array}$$

If as satisfactory results can be obtained by using the primary image which lasts from 1 to 20 seconds as by using the recurring images for a minute, the great saving of time is evident.

The experiments were performed in the Harvard Psychological Laboratory during the academic years 1913-14 and 1914-15. Fourteen subjects participated at various times in the work. Of these one was an instructor in the department, nine were graduate students (two of them women) and three were undergraduates of considerable psychological experience. The entire experiment comprises reports on approximately 5500 images.

The writer expresses his sincere obligations to Professor Herbert S. Langfeld and Professor Hugo Münsterberg.

III. EXPERIMENTAL RESULTS

A. *Complexity of Contour*

The results of the experiments on complexity of contour are summarized in Table I. The first column gives the subject. The next two give the results for single exposures,—the % superiority¹⁸ of the notched series to the simple, i. e., the % by which the average time of holding is greater, and the difference between the two averages divided by the probable error of difference. The next six give the results for simultaneous exposures. The introspective accounts fall readily into trials in which the notched or simple figure predomi-

¹⁸Percents reckoned in terms of the smaller figure throughout the work.

nates in imagery (i. e., is clearer or more persistent) or in which the two figures are equal. The table gives the % of the trials in which the notched predominates and in which the simple does so. Then follow the % superiority of the notched series to the check series (with both figures simple) in times of arousal and holding, i. e., the % by which the average time of arousal is less and the average time of holding greater, with the respective differences divided by the probable error of difference. The remaining columns give the results for successive exposures. The % of trials in which, according to the introspection, the figure exposed second predominates or appears alone in imagery in the series with the notched object shown first, is divided by the corresponding % for the normal series with both objects simple. A smaller ratio in the table indicates a greater effect of the complex first figure in reducing the natural predominance of the second figure. Then follow the % superiority of the series with the first figure notched to that with both figures simple in times of arousal and holding of imagery, with the corresponding differences divided by the probable error of difference. The temporal aspect of the image in the simultaneous and successive methods is not as important as the qualitative. It merely indicates whether the images rise more quickly and hold longer when one of the objects shown involves the given variable than when both are simple,—a factor measured more directly in single exposures.

The table shows that with 6 of the 7 subjects who participated on single exposures, the notched image holds longer on the average, than the simple, with an average superiority, including the negative case, of 11%. On simultaneous exposures the notched figure predominates in imagery in 69% of the trials as compared with 9% for the simple figure, while in the check series (not given in the table) the majority of the trials yield images that are equal. The images rise more slowly and hold longer on the notched series than on the check series.¹⁹ In successive exposures the second figure predomi-

¹⁹ It may be noted in passing that the whole series of experiments on imagery indicates that the time of holding is a much better criterion by which to judge the influence of various factors upon imagery, than is the time of arousal. The two times were correlated for 10 subjects on about 140 trials each by the Pearson produce-moments formula. There were three appreciable negative coefficients (.23, .30 and .34) and one positive (.29) while the others were small. In many cases the subjects get into a certain rhythm of arousal which is little influenced by the character of the stimuli. The time of holding correlates more often with the introspection.

TABLE I
COMPLEXITY OF CONTOUR

Subject	SINGLE EXPOSURE			SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE								
	TIME			REPORT			TIME			REPORT	TIME			REPORT	TIME			
	HOLDING			AROUSAL			HOLDING				AROUSAL				HOLDING			
	Percent- age of super- iority notched	Differ- ence P. E.		Notched predom- inate	Simple predom- inate	Percent- age of super- iority notched	Differ- ence P. E.		Percent- age of super- iority notched	Differ- ence P. E.		Notched normal	Percent- age of super- iority notched	Differ- ence P. E.		Percent- age of super- iority notched	Differ- ence P. E.	
<i>Br</i>	—3.0	1.6																
<i>Bz</i>				75%	17%	—27.2	3.8	18.9	4.6	.40	16.2	2.7	0	0				
<i>C</i>	14.2	1.5																
<i>D</i>				96%	4%	17.4	1.6	64.4	7.9	.12	—8.1	.8	14.1	3.1				
<i>F</i>	6.3	.9																
<i>H</i>	15.8	1.1																
<i>L</i>	28.8	1.5		25%	12%	—70.8	14.7	21.0	4.7	.43	—7.1	1.7	64.1	9.8				
<i>Ms</i>	2.7	1.0																
<i>Ml</i>	10.0	.8		80%	5%	—290.0	12.8	40.4	7.0	.43	22.7	1.7	4.5	.6				
<i>R</i>																		
Average.....	10.7	1.2		69%	9%	—92.6	8.2	36.2	6.1	.35	5.9	1.7	20.6	3.3				

nates in imagery about .35 as frequently when the first figure is notched as when both are simple, and the images in the former case rise somewhat more quickly and hold considerably longer than in the latter.

As a further light on the single exposure method a series was performed in which the visual stimuli were not presented. The subject sat in the same position as in the previous series with closed eyes and after the signal "ready" the experimenter named the object,—“notched square,” “simple square,” etc. The subject was to call up a memory image of the object as he had seen it a week before and signal its presence in the usual manner. The results tend in the same direction as the above,—the complex images holding longer for 5 of the 7 subjects with an average superiority of 8.5%.

The qualitative aspect of the results in some cases throws light upon the quantitative. There are, of course, individual differences in the color, clearness, position, etc., of the image and in its mode of appearance and disappearance. Such facts, although of general interest, do not concern the present problem. Mention will be made of only those points of introspection which indicate the effect of the variable under investigation.

On single exposures with *Br* kinaesthetic and affective factors seem prominent. The notched figures are frequently reported as “clear and pleasant.” The notched circle, however, is inferior in time of holding to the simple and is described as “vague kinaesthesia going around; not as pleasant as the plain circle; little jar as if rolling along and the rolling jerky; sort of kinaesthetic jar.” There is also a “tendency to look around it; less of this in the image.” *F* occasionally reports associations in connection with a figure that holds rather long in imagery. *H* notes that it is “easier to attend to the notched figure, for there is more complexity.” *L* is very kinaesthetic and often thinks of going around the figure or notes a “kinaesthetic image on a visual background” or a figure “filled in with kinaesthesia,” or “intimation of teeth on top and kinaesthesia below.” This kinaesthetic aspect seems to correlate with the longer holding of the notched image. However in the check series with word stimuli, he experiences great difficulty in getting an image at all of the notched figures. *Ms* notes on the notched circle, “Revolved; associated with pinwheel” or “Associated with circular saw; teeth slanted.” This associative factor tends to lengthen the time of the image. In the check series with word stimuli

the reports are somewhat similar to the preceding. *C* and *F* note movement of the eyes about the image of the notched figure. *L*, as just mentioned, has difficulty in calling up images of the notched figures and such images are less clear, slower of arousal and less persistent.

In simultaneous exposures *Bz* sometimes reports only the middle part of the two objects. This would seem to follow with the fact that the subject fixates between the two figures and the inner parts are consequently more in the focus of attention. *D* notes, "I try to divide the attention but I think the ragged one attracts me and the other fades first." *L* also shows a tendency for the portion nearest the point of fixation to be most marked in imagery. *R* states that the "notched ones were interesting."

On successive exposures *Bz* states that the notched ones are more interesting. With *L*, when the first object appears in imagery (as it does only in the notched series), it is frequently in kinaesthetic terms. In a number of trials the second takes on the notched attribute of the first. For example, "second with wavy lines;" "First, then second inside it crumply."

B. *Size*

The results of the experiments upon the influence of size are summarized in Table II which is identical in form with Table I except for the substitution of "large" for "notched" and "small" for "simple." The table shows that in single exposures the images of the larger figures hold 11% longer on the average than those of the small. On simultaneous exposures the large figure predominates in imagery in 32% of the trials as against 22% for the small figure, while the check series (not given) usually yields both images equal, and the images rise more slowly and hold longer on the series involving large objects than on the check series. On successive exposures the second figure predominates in imagery .76 as frequently when the first figure is larger as when both are of equal size and the images in the former case rise, in general, more quickly and hold longer.

As a further check on the single exposure method a series was performed in which the visual stimuli were not presented. The subject sat in the same position as in the previous series with closed eyes, and after the signal "ready" the experimenter named the object,— "large square," "small square," etc. The subject was to call up a memory image of the object as he had seen it a week before and signal its presence in the usual manner. The results tend to substantiate the above,

TABLE II
Size

Subject	SIMULTANEOUS EXPOSURE				SUCCESSIVE EXPOSURE					
	SINGLE EXPOSURE		TIME		REPORT	TIME				
	HOLDING		AROUSAL			AROUSAL				
	Percent- age of superi- ority large	Differ- ence P. E.	Percent- age of superi- ority large	Differ- ence P. E.		Percent- age of superi- ority large	Differ- ence P. E.			
			Large predom- inate	Small predom- inate		Large normal				
<i>Br</i>	8.0	1.3	42%	42%		.90	29.8	5.7	24.6	6.9
<i>Bz</i>	10.4	1.2	4%	4%		.91	19.4	2.2	20.0	3.4
<i>C</i>										
<i>D</i>										
<i>F</i>	1.3	1.6								
<i>H</i>	44.3	1.0								
<i>L</i>	9.2	2.4	31%	19%		.58	14.0	2.7	57.2	7.1
<i>Ms</i>	10.4	.9								
<i>Mt</i>	6.5	.6	50%	25%		.63	72.2	3.9	5.3	.8
<i>R</i>										
Average.....	11.0	1.3	32%	22%		.76	26.8	3.6	14.1	4.5

the image of the larger object holding 10% longer on the average.

A few points from the introspection may be noted. On single exposures with *Br* there is a possible correlation of time of holding with affective tone, the large figures being frequently reported as more pleasant. *C* notes that the large image sometimes "swells up" or "spreads out" at the end. *H* is "conscious of the effort to see the whole image; the eyes seem focussing one part and then another." *L* notes occasional kinaesthesia with the large figures. *Mt* states, "In looking at the object I tend to draw the part that interests me and the image has the heavy black line I have drawn." In the series with word stimuli *C* reports the large images much larger than the original. *F* notes the images as tending to build up. *L* finds the large images more difficult of arousal, e. g., "Mostly kinaesthetic; felt self pushing it out; tendency to make it small first; the pushing seems to be in the eye muscles; larger it is the longer it takes to get it." For *Ms* the large images are much larger than the original, often starting large and growing smaller.²⁰

In the simultaneous series *Bz* gets "the smaller figure as a whole, while with the larger it is a process of building up."

On successive exposures *L* notes occasionally the image of the second figure larger than the original. This is doubtless due to the influence of the first figure. He speaks of carrying in mind the difference in size.

C. Length of Exposure

The results of the experiments on length of exposure are summarized in Table III. Its form is like that of the preceding tables. The exposures were 5 and 10 seconds for the single exposure method. For the simultaneous, the apparatus was arranged so that one figure appeared alone and then the other beside it. A piece of 6 mm. board 25 x 10 cm. and painted black, was hinged to the edge of the tachistoscope with spring hinges in such a way that when a black thread was held taut one stimulus figure was obscured and when the thread was released the shutter flew back against the wall. The electrical connections were changed so that both contacts on the disc governing the exposures lighted the same lamp of the tachistoscope. The experimenter held the thread taut during the 6 seconds on the first contact and released

²⁰ It may be noted, as of methodological interest, that word stimuli have a greater effect in emphasizing an attribute of a figure than do the visual stimuli.

it at the slight flicker when the contacts changed. Thus the left stimulus appeared for 6 seconds and then both for 6 seconds. The subject fixated the first object and when both appeared fixated between them.²¹ In the table are given the per cent of trials in which the longer exposed of the two predominates and in which the shorter does so, with the per cent superiority in times of arousal and holding of the present series to the check series with the objects shown together an equal length of time. On successive exposures the variable was introduced by showing the second figure for one second and comparing such trials with the normal successive exposures of six seconds each.

The table shows that for single exposures the longer exposed object holds some 10% longer in imagery on the average, although 3 of the 7 subjects show slight negative tendencies. The average results on the simultaneous method are identical for the long and short series. This is due to two subjects, *D* and *L*, whose introspection (*infra*) indicates the entrance of another factor. The average difference in the temporal aspect of the image under these conditions is slight. On successive exposures the second figure predominates about .81 as frequently when its exposure is shortened to one second as when both are shown for 6 seconds. The times are not given in the table as they show only slight differences in both directions. If, however, the holding time on the 6 and 1 second series is evaluated for the trials in which the first object predominates compared with those in which the second does so, the average of the former is 18% superior to the latter with the differences 2.4 the probable error on the average. In other words the imagery does not hold as long when the object exposed for 1 second predominates as when that exposed for 6 seconds predominates,—a result similar to that found with single exposures.

A few points from the introspection may be noted. On simultaneous exposures *A* frequently gets an "exact reproduction of the original; first one and then both." Evidently the distribution of attention in the image follows that in the stimulus. *Bz* says, "I take in the first one more quickly than the one beside something already in attention; feels as if the

²¹ No other method of studying this factor from the simultaneous standpoint seems available. Showing one object alone in the center of the field followed by the same object with another beside it has merely the effect of successive exposures, and the first, when it does appear in imagery, is in the center like the original stimulus. Showing both objects and then cutting out one would leave the effect of recency which is pronounced on all the work on successive exposures.

TABLE III
LENGTH OF EXPOSURE

Subject	SINGLE EXPOSURE			SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE
	TIME		HOLDING	REPORT		TIME				REPORT
	HOLDING			Long exp. predominate	Short exp. predominate	AROUSAL		HOLDING		
	Percentage of superiority long exp.	Difference P. E.				Percentage of superiority long exp.	Difference P. E.	Percentage of superiority long exp.	Difference P. E.	
A	11.2	2.2	45%	10%	-29.0	.9	-15.7	1.4		
Br										
Bz	17.0	1.6	100%	0%	.4	.1	-22.5	7.1	.86	
C										
D			0%	100%	7.8	1.3	21.1	3.7	1.00	
F	-5.5	.5							.26	
G									1.00	
H	36.5	1.1							.46	
K									1.03	
L	-2.8	.2	15%	77%	-2.6	.5	21.0	2.2		
Ms	17.2	1.6								
Mt	-4.4	.7	49%	22%	6.1	.7	-2.1	.4	1.12	
R									.69	
T										
Average....	9.9	1.1	42%	42%	-3.5	.7	-.4	3.0	.81	

attention swung back to it after closing the eyes; fact it has been there longer turns the attention to it." *D* always gets the shorter exposed figure clearer in imagery. In the early trials it is covered with a "veil," but the image of that one is nevertheless clearer. Toward the end the veil is "not present so much as its effect in making the image blacker and attracting attention to it." Probably the stimulus to attention of the screened objects accounts for the results. "Knowing it is screened arouses curiosity and interest in it when it comes; there is a tendency to go to the veiled object when it appears, although I try to fixate between them." *L* reports a "decided feeling of something coming in; I fixate the first and when I move to the middle it throws the attention to the other side; I feel the attention go." The results of *D* and *L* thus cannot be considered as evidence against the positive effect of exposure length, for owing to the technique of the experiment other variables entered with them,—in the case of *D* the factor of interest in the concealed object which is to appear, and with *L* the overshooting of the motor impulse or attention in turning from one figure to the mid-point between the two.

On successive exposures with *Bz* the effect of shortened exposure is more marked than the table indicates. In the trials where the second figure predominates he states that "it is not as dominant on the shortened exposure; in the normal, the first object appears in imagery only at the end, whereas with the shortened exposure it appears relatively earlier." With *D* the second object is relatively clearer in imagery in the series with shortened exposure,—a result the opposite of the general tendency. The following introspection explains the fact: "During the second exposure I recall the first by kinaesthesia; on the short exposure the first does not have time to come into relation with the second; the kinaesthesia of the first cannot arise during the second as it usually does." *L* reports that with the short exposure the images "come immediately and are more involuntary than with the longer exposure." *K* shows a similar tendency. With *Ms* and *T* one figure carries associations and tends to predominate whether shown first or second.

D. Interest

The results of the experiments upon the rôle of interest are summarized in Table IV. Its form is identical with that of Table I with the interesting figure substituted for the complex. The table shows that on single exposures the images

hold somewhat longer for the meaningful figures. Some of these figures, however, were much more interesting than the others. If the results for the three most interesting stimuli are averaged together, they hold 18% longer than the average of the normal series. In simultaneous exposures the interesting figure predominates in imagery in 47% of the trials as against 10% for the meaningless figure, whereas in check series with both figures simple, the majority of the trials yield equal images, and the images hold 4% longer in the former case. On successive exposures with the first object interesting the second predominates in imagery only .33 as frequently as when both are meaningless, while the images rise more quickly and hold longer under the former condition.

The following points in the introspection may be noted. In single exposures associations are frequent in connection with the imagery of all but the two most kinaesthetic subjects *L* and *Mt*. The figures that yield for a given subject the most associations are usually held by him longer in imagery than the other figures. With *F* there is a possible correlation between the time the image holds and the pleasantness of the associations. With *Br*, *C* and *Ms* the images tend to become the real objects represented instead of the plane figures.

In simultaneous exposures the factor of interest is mentioned by all the subjects. With three, *Br*, *Ms* and *Mt*, there is a tendency for the images to become real objects. There is frequently a change in predominance of an interesting object as the series progresses and the same object occurs several times. Toward the end of the series the images tend to be more nearly equal. This occurs with five subjects. As *Br* says, "The reason they even up in clearness is because at the beginning there is more difference in meaning. As I go along with it, the one tends to lose some of its associative value through repetition and the other tends to get a meaning. You exhaust the interest of one object and try to get interest for the other." Or as *H* states, "One object attracts the attention more at first, but after becoming familiar with it, it is easier to distribute the attention."

On successive exposures *Bz* states that "the more interesting it is the more it gets into consciousness." *Bz* and *R* have a tendency for the outline figures to become real objects in imagery. There is further a tendency with three subjects for the interest to wear off with repetition and affect the imagery. Considering the successive trials the second figure predominates more frequently toward the end of the series.

TABLE V
MOTOR REINFORCEMENT

Subject	SINGLE EXPOSURE				SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE		
	TIME				REPORT		TIME				REPORT	TIME	
	AROUSAL		HOLDING		Traced predomin- inate	Other predom- inate	AROUSAL		HOLDING		Traced normal	HOLDING	
	Percent- age of superi- ority traced	Differ- ence P. E.	Percent- age of superi- ority traced	Differ- ence P. E.			Percent- age of superi- ority traced	Differ- ence P. E.					
									Percent- age of superi- ority traced	Differ- ence P. E.			
<i>Bz</i>	-8.6	2.2	1.3	.2	95%	0%	10.7	2.2	24.4	4.9	.14	97.0	26.0
<i>Bz</i>											.09*	33.3	4.7
<i>D</i>	9.0	1.5	31.0	7.2	100%	0%	-36.2	3.4	10.8	2.0	.04*	2.6	.4
<i>F</i>											1.01	-62.8	12.7
<i>H</i>											1.00	-72.4	16.5
<i>K</i>											.69	-51.3	5.1
<i>L</i>	16.0	3.8	1.2	.3	40%	45%	-5.9	2.2	9.6	1.9	.91	-40.0	6.1
<i>Ms</i>											.08	14.2	4.2
<i>R</i>	-23.0	1.9	31.0	3.2	80%	10%	-260.0	11.1	6.5	.9	.74	-8.5	1.3
<i>R</i>											.42*	13.0	2.1
<i>T</i>											.67	300.0	23.0
Average.....	-1.4	2.3	16.1	2.7	79%	14%	-72.8	4.7	12.8	2.4	.53	20.2	9.3

* Check series; performed later.

E. Motor Reinforcement

The results of the experiments on motor reinforcement produced by tracing with a pencil on the table the outline of the figure fixated, are summarized in Table V, which is similar in form to the previous tables. On simultaneous exposures the subject fixated between the figures while tracing one of them. The table shows a slight average difference on single exposure between the tracing and the normal series in times of arousal, but a 16% superiority of the latter in time of holding. On simultaneous exposures the traced object predominates in 79% of the trials as compared with 14% for the other object. The images in the tracing series rise much more slowly and hold considerably longer than in the check series with no tracing. The delay of the images on the tracing series is probably due to the confusion of having in the hand the pencil with which the tracing was done, and the necessity of laying down the pencil or signalling with the other hand. On successive exposures with the first object traced the second predominates only .53 as frequently as when no tracing is done, and the images hold 20% longer on the average under the former condition.

The introspection indicates further how the tracing tends to reinforce the imagery. On single exposures *Bz* notes, "Tracing helps; the eyes go around it and the eye muscles repeat in imagery; see the images usually as enclosed spaces but with tracing I see the edge more." "Trace the triangle with the eye on the apex and it comes that way in the image." The distribution of attention in the image thus follows that of the exposure. *D* shows a similar tendency. "Image is as I draw it, e. g., imperfections in the angles I draw." *L* feels "kinaesthesia during the image, mostly in the arms." He further notes a "better control of the image when traced." *R* has a "tendency to trace the image; like eye movement, or as if the line ran around." Again, "Image comes from the tracing; sometimes forget what was shown but remember it by movement of the hand; think the tracing does not add to it except when I forget image and remember it kinaesthetically."

On simultaneous exposures the only reports of interest are those of *L*: "Try to divide attention, fixate between them and trace automatically; this causes alternation of attention between one object and the other and in imagery the figures frequently alternate."

On successive exposures *Bz* frequently reports kinaesthetic imagery in conjunction with the visual, and this kinaesthetic

imagery is of the first object. He further adds, "It helps to work the kinaesthetic and visual together; the kinaesthesia brings up the visual; it fixes the outlines better; the eyes go around more on the tracing although they sometimes do so on the normal." *D* tends to "have an idea of the first object in kinaesthetic terms while looking at the second." This tendency has been noted by *D* in other series. In the present case it is more marked on the tracing series than on the normal. With *H* the second object always appears alone. She shows here and elsewhere a pronounced tendency toward immediate arousal of imagery of the object just seen,—a marked visual perseveration. *K* notes a change from a visual to a motor attitude. "Tracing often lessens interest in looks; there is a change of attitude in some figures it rules out the bad parts while others I do not like unless I trace them." *L* finds occasionally a "motor memory of the first while looking at the second,—a thought of the movements of the hand." *Ms* occasionally reports kinaesthetic imagery in conjunction with the visual and in general "likes to trace them." *R* sometimes finds that "kinaesthetic images bring up the first object." He finds that "tracing concentrates the attention."

F. *Motor Distraction*

The results of experiments on motor distraction are summarized in Table VI. The distraction was produced by writing on the table extraneous words of three or more syllables during fixation. The word was given before the object appeared on single exposures and one second before the second object appeared on successive exposures, and the subject wrote and rewrote the word during fixation. It was not possible to test the factor of motor distraction directly with simultaneous exposures because the distraction would naturally involve both objects. The best approach to the problem seemed to be to direct the motor attitude to the objects alternately and see if in the subsequent imagery the attention would follow a similar course. Tracing one object would serve as a distraction from the other and so there would be an alternating distraction and an alternating reinforcement. The experimenter said, "Right, left, right, left" during the exposure in time with the swings of a pendulum properly adjusted, starting alternately with right and left in successive trials. The subject traced on the table the object designated, and in most cases there was time to trace it only once.

The table shows no unanimous tendency on single exposures. On simultaneous exposures with alternate tracing the images

TABLE VI
MOTOR DISTRACTION

Subject	SINGLE EXPOSURE			SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE			
	TIME		HOLDING	REPORT	TIME		HOLDING	REPORT	TIME	HOLDING			
	AROUSAL	Percent- age of superi- ority normal			Differ- ence P. E.	AROUSAL					Differ- ence P. E.		
						Percent- age of superi- ority normal						Differ- ence P. E.	Percent- age of superi- ority normal
	Percent- age of superi- ority normal	Differ- ence P. E.	Images—alternate		Percent- age of superi- ority normal		Differ- ence P. E.	Percent- age of superi- ority normal	Differ- ence P. E.	Write normal	Percent- age of superi- ority normal		
Writing			Normal										
Bz	7.0	1.4	.7	.7	55%	0%	3.4	4.5	46.6	6.3	.51	-41.3	9.9
Bz											.18*	-17.0	2.1
D	-6.0	1.2	-4.6	.6	100%	0%	-3.3	.3	66.0	5.8	.30*	5.2	.8
H											1.0	166.0	15.5
K											.92	60.5	6.9
Ms											.24	84.0	13.4
R	37.0	3.2	-26.0	2.9	0%	0%	-15.7	1.3	-42.1	5.3	1.23	61.7	9.1
R											.75*	9.9	1.7
T											.97	-111.0	28.0
L	-12.7	3.1	8.0	1.7	58%	0%	-10.5	1.4	-5.2	.9			
Average.....	6.1	2.2	-5.5	1.5	53%	0%	-6.5	1.8	16.3	4.6	.68	24.2	9.7

* Check series; performed later.

alternate in 53% of the trials whereas normally they never alternate. They rise more slowly and hold longer under the former condition, but it is doubtful as to what is thus indicated,—reinforcement or distraction. In successive exposures with motor distraction on the second object it predominates only .68 as frequently as on the normal series and the images hold 24% longer on the normal series.

On single exposures *Bz* frequently writes automatically and keeps the attention on the figure. There is also a "tendency to name some of the figures when writing a hard word,—motor reinforcement to make it persist, and after the flash the vocal cords say 'semi-circle' and there is more effort put forth to get the image under these conditions." *D* states that the "writing takes away from the clearness of the image; it takes away the attention." *L* finds the "spelling automatic," and speaks of the attention as "divided between work and figure." *R* also finds that "the writing is automatic and does not distract at all even if there is a visual image of the word and the hand." "It is more pleasant to write than not to; it relieves the monotony of fixation."

On the simultaneous series with alternate tracing *Bz* is conscious of eye movements. "I keep the eyes in the direction of the one last looked at; I think the attention goes with the eye muscles; effort to keep the eyes still when the flash comes." *D* notes a "feeling as if the eyes were turning." *L* gets the image in "nearly the same distribution as the object." It may be noted that in the trials in which the images alternate, with *Bz* and *L* the alternation starts with the figure last looked at, while with *D* it starts with the other, i. e., the figure presented first in the tachistoscope. There is one exception in the case of each subject.

On successive exposures *Bz* reports, "If I write carefully it has a distracting effect." Sometimes he keeps "repeating the word during the image." *D* shows two tendencies. The table shows that the writing detracts from the second object in about 70% of the trials. But in the remainder the second object is relatively much clearer than in the normal series. *D* states that the "words sometimes take away from the first although they on the whole detract from the second." He can write automatically. Further, "Normally I get an idea of the first kinaesthetically while looking at the second, and when writing I ignore this." Evidently the writing sometimes operates as a distraction from the second object, and sometimes distracts from the kinaesthetic persistence of the first during the exposure of the second. *K* shows very slight

influence of the writing on the whole. He states, "Tracing the word seems to wipe out the kinaesthetic aspect of the first,—my whole kinaesthetic set as a real object; the movement may interfere with the kinaesthesia that normally develops; tracing seems to wipe out the perseveration of the first." Again, "Tracing does not seem to interfere with the image if I name the first object." Presumably these two tendencies balance one another in the results indicated in the table.

G. *Mental Distraction*

The results of the series with mental distraction are summarized in Table VII. The distraction was produced by performing continuous addition aloud, starting with one number and adding a second to it and continuing to add the second to the resulting sum. On the single exposures and on the successive with distraction on the first figure, the numbers were given about 2 seconds before the appearance of the figure,—instructions such as "17 add 24." On successive exposures with distraction on the second figure, the first number was given before the trial and the other number 1 second before the appearance of the second figure.²² On the simultaneous method as on the series with motor distraction it was not feasible to test the variable directly. The subjects fixated the figures alternately making four alternations per exposure as directed by the experimenter's signal, "Right, left," etc.

The table shows that on single exposures without distraction the images hold 17% longer than when addition is done during fixation. On simultaneous exposures with alternate fixation the images alternate in 45% of the trials whereas they never do normally. When the distraction is given on the second figure it predominates about .82 as frequently as normally and when the distraction is given on the first figure the second predominates .15 more frequently than normally. The only large differences, however, are with *Bz* and *Ms*. With distraction on the first or second figure the images hold somewhat less than on the normal series.

On the single exposure series *Bz* finds the addition a "pronounced distraction." Consequently he finds that "when the adding is hard I want to shut my eyes for fear of making a mistake." He has been a school teacher and feels badly if a mistake is made. *D* simply says that the "addition takes

²² This was to enable the subject to start promptly on the addition although not starting during the first exposure as might be the case if the numbers were both given at the outset.

TABLE VII
MENTAL DISTRACTION

Subject	SINGLE EXPOSURE		SIMULTANEOUS EXPOSURE		SUCCESSIVE EXPOSURE					
	TIME		REPORT		REPORT		TIME			
	HOLDING		Images—alternate		Add on		HOLDING		HOLDING	
	Percentage of superiority normal	Difference P. E.	Alternate fixation	Normal	second normal	first normal	Percentage of inferiority second	Difference P. E.	Percentage of inferiority add on first	Difference P. E.
<i>B₂</i>	31.0	3.0	25%	0%	.29*		—9.8	2.9	—86.0	22.3
<i>B₂</i>					.42	1.27	17.5	2.8		
<i>D</i>	21.0	2.9	87%	0%						
<i>F</i>					.90	1.04	—29.8	9.6	15.8	5.3
<i>G</i>					1.02	1.23	28.8	8.0	70.3	13.8
<i>H</i>					1.00	1.00	125.0	24.0	34.4	13.0
<i>K</i>					.98	1.08	17.6	2.5	53.0	6.0
<i>L</i>	18.0	3.4	66%	0%	1.03	1.01	12.0	3.1	33.3	8.5
<i>M_s</i>					.59	1.45	25.0	6.8	53.0	11.3
<i>R</i>	—1.3	.6	0%	0%	1.08	1.24	62.3	9.2	44.0	7.1
<i>R</i>					.84*		—17.0	2.1		
<i>T</i>					.92	1.00	—206.0	24.8	—157.0	19.7
Average...	17.2	2.5	45%	0%	.82	1.15	4.1	8.6	6.7	11.8

* Check series; performed later.

the attention from the imagery and makes the image less clear." *L* finds the arithmetic "a great distraction, more so than the writing." Occasionally when distracted he "gives it a good look at the end." *R* says, "If I put the attention on the adding it reduces the imagery."

On simultaneous exposures the reports are almost identical with those on motor distraction (*supra*). *Bz* and *D* note eye movements with the alternating images, while *L* notes the distribution of attention in the image almost identical with that in the stimulus. With *Bz* and *L* the alternation starts with the figure last looked at, and with *D* it starts with the figure that was exposed first.

On successive exposures the introspection indicates that the adding in general affords a distraction. The noticeable thing, however, in Table VII is the marked results for *Bz* and *Ms* and the slight difference for the other subjects. This result might be due to one of several causes: (1) individual differences in the actual effect of attention upon imagery, i. e., whether a conscious visual impression is necessary for the arousal of the image; (2) individual differences in the method of addition,—e. g., whether visualizing the numbers interferes with the visual impression; (3) differences in the degree of attention devoted to the addition,—whether it always occupies the focus and whether the attention fluctuates.

The first of these possibilities would seem to be ruled out by the fact that both *Bz* and *Ms* report trials in which the image appears without there having been a conscious impression of the stimulus, and two other subjects do likewise. As to the second, in a series of tests upon ability in continuous addition under visual distraction *Bz* and *Ms* show a slight loss in efficiency as compared with their normal rate, but four other subjects show the same tendency. Moreover *Bz* visualizes the numbers and *Ms* does not. The third alternative remains and a survey of the introspection tends to substantiate it. Most of the subjects give occasional reports that would indicate fluctuations of attention during the addition, or addition performed with varying degrees of attention. The two crucial subjects do not show these fluctuations. *Bz* adds with a high degree of attention. He "likes to get up to 100." He hates to make a mistake in addition. It is to be noted that in the previous series on single exposures he shows the effect of the distraction the most markedly of the subjects. *Ms* finds that "when the addition went well it attached a pleasant effect to the object and when it went poorly it took the attention from the object." As a matter of fact it seldom

went well and his general opinion at the end of the series was that he "hated it." It is probable that with these two subjects the mental state while observing the object and doing mental addition approaches more nearly and constantly to complete distraction from the object.

Thus the fact of the influence of attention upon imagery which has been more or less manifest throughout the entire investigation receives definite corroboration. Although a complete control of attention is impossible, the results give rather strong indications of the importance, for imagery, of attention bestowed upon the stimulus.

IV. SUMMARY

A. *General Tendencies*

The preceding experiments have investigated the rôle in imagery of complexity of contour, size, length of exposure, interest, motor reinforcement, motor and mental distraction. Each of these variables was applied to a stimulus object and the effect upon subsequent imagery noted. Three methods were used in each case,—single, simultaneous and successive exposures,—with fairly consistent results. The first five variables mentioned tend quite generally to reinforce visual imagery and facilitate its arousal, and the last two have the opposite effect. If the general averages at the bottom of the columns in Tables I-VII are considered it is evident that the smallest differences are shown by all three methods for size and length of exposure. Motor reinforcement yields a marked effect by all methods, and interest also ranks quite high. The effect of complexity and motor distraction is considerable in simultaneous and successive, and that of mental distraction in single and simultaneous exposures.

B. *Individual Differences*

Average results must not be allowed to obscure the individual differences, for while the subjects nearly always show the influence of the factors in question, there are great differences in degree. Furthermore the introspection reveals that the given factors operate by different means with the different individuals.

If the results for the subjects who participated in the experiment on a number of variables are followed through Tables I-VII, it is evident that individuals vary as to the factor that most affects them. For instance, *Bz* seems most affected by motor reinforcement and least by size. *D* is most

susceptible to motor reinforcement and least to lengthening of exposure. *L*'s imagery is most facilitated by interest and least by lengthening of exposure. *R* is most influenced by complexity of contour and least by distraction.

In the course of the work a number of individual tendencies have been brought out. The salient points for each subject may be briefly mentioned.

Br notes the presence of kinaesthetic factors during the presentation of the stimulus, which apparently facilitates the subsequent imagery.

Bz works kinaesthetic imagery to aid the visual and in addition to central kinaesthesia actual eye movements are frequently noted. The distribution of attention during the stimulus is a great factor in influencing imagery. If one part is fixated that part becomes clearer in imagery.

C has a tendency to accentuate attributes of the stimulus such as size.

D on successive exposures has a tendency toward a persistence of the first object in kinaesthetic terms during the exposure of the second. Any distraction during the second or a shortening of its exposure tends to interfere with the persistence of the first and to detract from its subsequent imagery. Much depends too upon distribution of attention during the stimulus period.

F shows considerable play of associations with simple figures and this correlates in general with reproductivity of the figures in imagery. It is the pleasant associations that have the greatest effect.

H's most marked feature is a pronounced visual perseveration. In single and simultaneous exposures the images usually appear very quickly and exactly reproducing the stimulus object. In successive exposures the second object appears alone in imagery under all conditions, and rises quickly.

K shows like *D* a kinaesthetic persistence of the first object during the second on successive exposures. Distraction on the second militates against imagery of the first.

L reports far more kinaesthesia than any of the other subjects. The visual image is frequently filled in with kinaesthesia. In the voluntary arousal of a visual image with merely a word stimulus, he experiences great difficulty in getting a visual image at all. Kinaesthetic imagery is sometimes used to mediate the visual. On successive exposures there is frequently a motor memory of the first object during the second. The distribution of attention in the imagery follows that in the stimulus. In some cases an attribute of an

object appears in imagery although the object itself does not do so.

Ms has a great play of associations. The objects tend to become real in imagery with a very definite and complex context. This tendency correlates with reproductivity to a considerable extent. He also occasionally notes kinaesthetic imagery in conjunction with the visual.

Mt has kinaesthesia frequently in connection with the visual imagery. She feels it would be easier to draw the figure than visualize it, and there is a tendency to draw the part that is interesting.

R, after tracing an object, often recalls it for visual imagery by an actual movement of the hand. In many other instances he names the object as an aid in recalling it.

C. Conclusions

1. Complexity of contour of a plane figure, increase of its size, lengthening of its exposure, interest aroused in it and motor reinforcement by tracing its outlines during fixation tend, in general, to facilitate the arousal of visual imagery of that figure. Distraction by performing mental arithmetic or by writing extraneous words during fixation has the opposite effect. The results are, on the whole, most marked with motor reinforcement and with interest, and least marked with increase of size and lengthening of exposure.

2. Individuals differ in their susceptibility to the above factors. The visual imagery of some is most influenced by motor reinforcement; of others by interest; and of others by complexity of contour.

3. Individuals differ further in the means by which these factors operate. The principal points of difference are:

A. Other imagery,—notably kinaesthetic,—is with some individuals involuntarily employed to reinforce or mediate the visual. There may be kinaesthetic imagery of the movement of the hand or eyes around the contour of the object, or verbal imagery of its name.

B. Some individuals have a kinaesthetic persistence of a visual stimulus immediately after its disappearance, and interference with this detracts from subsequent visual imagery of the object.

C. Distribution of attention during the stimulus period conditions with some individuals the distribution of attention during the subsequent imagery.

4. It seems probable that the factors studied in the present experiment are somewhat interrelated and converge toward

a single factor,—the directing of attention to the stimulus object. The introspection indicates that the effect of complexity of contour and the effect of size are due primarily to motor elements. The motor aspect, in turn, is described as producing a greater concentration of attention. Interesting material is reported as arousing associations and stimulating attention to a greater degree. When the attention factor is made the subject of specific study by means of distraction during fixation of visual stimuli, the results show that, although in certain sporadic cases the arousal of imagery of the stimulus may proceed entirely involuntarily, a higher degree of attention devoted to an object generally facilitates the arousal of imagery of that object.

5. Apart from the question of "visual type," there are individuals who can reproduce a visual image immediately, and others for whom the visual is mediated or reinforced by imagery (or in some cases sensation) of another mode,—notably kinaesthetic. Grouping of individuals on the basis of such a tendency shows no correlation with a grouping on the basis of clearness of persistence of imagery.